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(54) **Acoustic absorber**

(57) An intake system for an internal combustion engine is disclosed having an intake air duct (10) for transferring intake air to the engine. The inlet air duct has an acoustical tuner (12,12') in operable communication with the intake air flow to attenuate sound frequencies in the duct. The tuner has a first, opened end (16) which communicates with the air flow in duct (10), a tubular body (14) and a second end (18) which is closed by a moveable diaphragm (20). The diaphragm is moveable under the force of a sound wave traversing the tuner and is operable to extend the attenuation range of the tuner.

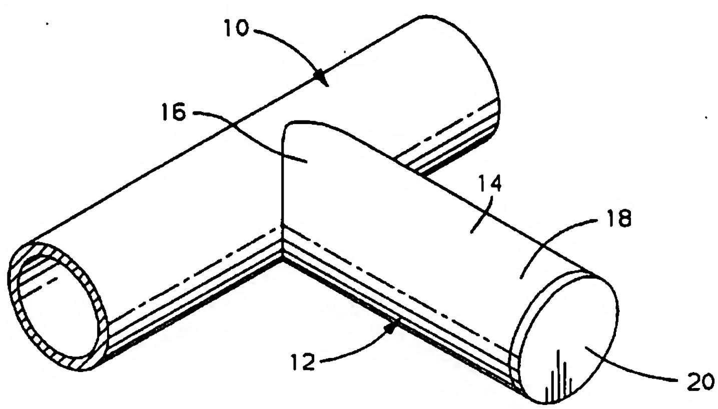

FIG. 1

Description

TECHNICAL FIELD

The invention relates to passive cancellation of noise generated in a gas carrying duct and, in particular, to an air induction system of an internal combustion engine having a modified acoustical tuner.

BACKGROUND

The air induction system of an automotive internal combustion engine can be a source of undesirable noise. Passive noise cancellation techniques have employed resonators or tuners which are connected to the intake system and are operable to attenuate specific frequencies. An example of such a tuner is a quarter-wave tuner which is typically a tube having a length which is roughly equal to one-fourth of the wave length of the sound energy to be attenuated. Generation by the induction system of the tuners natural frequency will result in a reflected waveform of the same frequency and amplitude but of opposite phase. The tuner generated waveform cancels the induction noise at that frequency.

The tuners are typically constructed of a tube having an open end in communication with the induction system and a closed end. Alternatively, such a tuner may comprise a cylindrical body with both ends closed and an opening midway between the two ends which communicates with the induction system. Maximum sound pressure points are created along the length of the intake system with the locations of the points dependent upon the length and configuration of the specific intake. The opening to the tuner communicates with the intake at the pressure point for the frequency to be attenuated and can, as a result, significantly attenuate the generated noise at that frequency. Along with the reduction in noise generated in the narrow band addressed by such tuners may come undesirable side frequency peaks on either side of the absorbed frequency peak. Although reduced significantly from the attenuated frequency peak, these side frequency peaks can be the source of additional generated noise.

SUMMARY OF THE INVENTION

The present invention is directed to an acoustical tuner for use in the attenuation of noise generated from a gas carrying duct such as is commonly used in the intake systems of internal combustion engines. The tuner of the present invention may be constructed as a tube having a length corresponding to the wavelength of the sound energy to be attenuated. The tube is placed in communication with the gas carrying duct at a location along the duct at which a high pressure point for the wavelength of the sound to be attenuated exists. Such a location has to be determined for each configuration of gas carrying duct, as the location of the points will depend on the specific configuration.

The acoustical tuner, to which the present invention is directed, may also include a second, closed end which is constructed of a moveable diaphragm. A sound wave entering the tuner from the gas carrying intake duct will be reflected from the closed end and returned to the open end in phase-opposition to the duct carried sound wave of the same frequency. In addition, the movable diaphragm moves outwardly as the sound wave impacts the closed second end. The outward movement, and subsequent return of the diaphragm to its original location, converts acoustical energy to mechanical energy while changing the effective tuned length of the tuner. The resultant frequency attenuation of the disclosed tuner is operable over a larger frequency range and, more specifically, over a portion of the range of undesirable side frequency peaks which may be generated when using an acoustical tuner having ends of conventional design.

The present invention will now be described, by way of example, with reference to the accompanying, description and to the drawings, in which:

Figure 1 is a perspective view, partially in section, of an acoustic tuner embodying features of the present invention;

Figure 2 is a perspective view of a second embodiment of an acoustic tuner embodying features of the present invention; and

Figure 3 is a graphic representation of noise levels generated in a gas carrying tube having varying levels of sound attenuation.

Referring to Figure 1, an inlet duct 10 for an internal combustion engine (not shown) is illustrated having a sound attenuating acoustical tuner 12 attached to the side thereof. The intake duct 10 will typically extend from a first opened end at which point engine air enters the duct to a second end at the inlet to each engine cylinder. The duct may comprise several different components and is rarely straight, due to packaging considerations. Noise sources from the engine radiate sound through the intake duct which, if unchecked, will exit the inlet duct in the form of undesirable external noise. The sound waves travelling through the duct 10 establish maximum sound pressure points along its length. Attenuation of the sound wave frequencies which produce the maximum pressure points is typically addressed by connecting the first,opened end 16 of an acoustical quarter-wave length tuner 12, to the inlet duct 10, at the location of the pressure points.

The quarter-wave tuner 12, shown in figure 1, includes a tubular body 14 which extends radially outwardly from the inlet duct 10 and is terminated at a closed, second end 18. The total length of the tuner 12 approximates one quarter the wave length of the frequency producing the sound pressure point to be attenuated. When a sound wave enters the first end 16 of tuner 12 it traverses the length of the tube 14 and is reflected by the closed second end 18 of the tuner as a waveform with the same frequency and amplitude but

opposite in phase so as to cancel the induction noise at that frequency. The operation of the quarter-wave tuner described thus far is illustrated in Figure 3 in which line "A" illustrates the sound characteristics of an unattenuated system, and line "B" illustrates the attenuation achieved by application of a quarter-wave tuner as described thus far.

The side frequency peaks of curve "B" which are generated using the quarter-wave tuner are further attenuated by the application of a movable, diaphragm 20 to the closed, second end 18 of tuner 12. The diaphragm 20 is preferably constructed of an inelastic material such as metal or semi rigid plastic. The diaphragm closes the second end 18 of the tuner 12 in a "limp" fashion as opposed to being drawn taught, across the second end which could radiate additional sound energy in much the same way as a drum. As a sound wave moves through the tube 14 and impacts the diaphragm 20 at the second end 18, a pressure build-up at the second end moves the diaphragm outwardly resulting in a change in the effective length of the tuner 12 and a conversion of a portion of the sound energy to mechanical energy. Similarly as the sound wave is reflected back, towards the first end 16 of the tuner 12, the diaphragm 20 is pulled inwardly, expending further sound energy in the form of mechanical energy. The effect of the in and out movement of the diaphragm 20 is the conversion of acoustical energy to mechanical energy with a resultant broadening of the attenuated sound frequency to include the side frequency peaks which are present after attenuation by a standard quarter-wave tuner. Line "C" in Figure 3 illustrates the additional attenuation available through the used of the diaphragm 20 in the second end 18 of the tuner 12.

Figure 2 illustrates a second embodiment of the present invention in which a tuner 12' is constructed of two lengths of tube 22,24 placed in series and coupled by a bend 26 in the tuner. At the terminus of the first length of tube 22 and integral with the bend 26 in tuner 12' is a first diaphragm 28. Similarly at the terminus of the second length of tube 24 and integral with the second end of tuner 12' is a second diaphragm 30. The tuner 12' of Figure 2 operates on more than one frequency peak in inlet duct 10'. The first length 22 of tuner 12' operable to attenuate frequency peaks associated with its length and, in addition, the first and second lengths 22 and 24, operable to attenuate frequency peaks associated with the cumulative lengths thereof. As with the embodiment of Figure 1, described above, the diaphragms 28 and 30 extend the effective attenuation of the tuner 12' through the conversion of acoustic energy to mechanical energy as the diaphragms are moved outwardly and, subsequently, returned to position to thereby vary the effective length of the tuner sections.

The second diaphragm 30 of the tuner 12' shown in Figure 3 is shown with an additional embodiment of the present invention. It may be desirable to add a mass 32 to the surface of the flexible diaphragm. Such a mass can add to the energy dissipating effect of the diaphragm which may be desirable in further attenuating noise frequencies in the duct 10'.

While the preferred embodiments of the present invention have been disclosed in their application to the intake duct of an automotive internal combustion engine, the invention should not be limited to that specific application. It is contemplated that such an apparatus for the reduction of generated noise in a gas carrying duct has further applications in such areas as the engine exhaust system and other fluid carrying conduits.

Claims

1. An acoustical tuner for attenuation of a sound frequency within a gas carrying duct, said tuner comprising a tubular body having a length corresponding to the wavelength of the sound frequency to be attenuated, a first, open end for communication with said duct and a second end closed by a diaphragm member, said member moveable under the force of a sound wave traversing said tuner to extend the attenuation range of said tuner beyond the frequency associated with the length of said tuner.

2. An acoustical tuner, as defined in claim 1, said tubular body having a length corresponding to one-quarter the wavelength of the sound frequency to be attenuated.

3. An acoustical tuner, as defined in claim 1, said diaphragm member constructed of an inelastic material.

4. An acoustical tuner, as defined in claim 1, said diaphragm member having a mass fixed thereto, operable to increase the energy dissipating effect of movement of said diaphragm.

5. An air induction system for an internal combustion engine comprising an intake air duct for transferring intake air to said engine and an acoustical tuner for attenuation of a sound frequency within said intake air duct, said tuner comprising a tubular body having a length corresponding to the wavelength of the sound frequency to be attenuated, a first, opened end in communication with the interior of said intake air duct and a second end closed by a moveable diaphragm member, said member moveable under the force of a sound wave traversing said tuner to extend the attenuation range of said tuner beyond the frequency associated with the length of said tuner.

6. An acoustical tuner, as defined in claim 5, said tubular body further comprising a bend therein, intermediate of said first end and said second end, and located a distance from said first end which corresponds to a wavelength of a second sound frequency to be attenuated, said bend defining a second quarter-wave acoustical tuner integral with

said first tuner, and a second diaphragm member located at the apex of said bend and moveable under the force of a sound wave, of the frequency associated with said second tuner length, traversing said distance from said first end to said bend to extend the attenuation range of said second tuner beyond the frequency associated therewith.

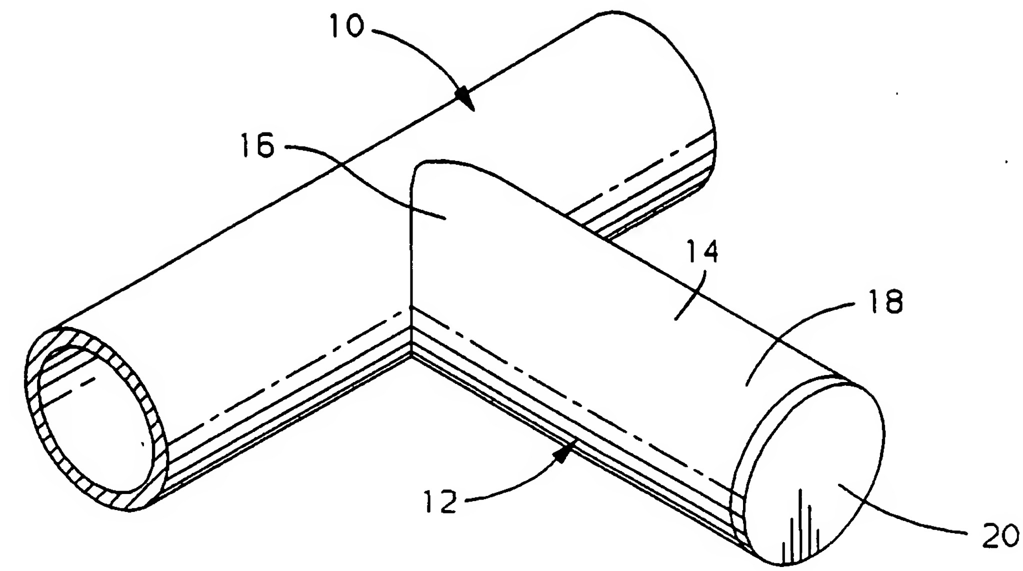

FIG. 1

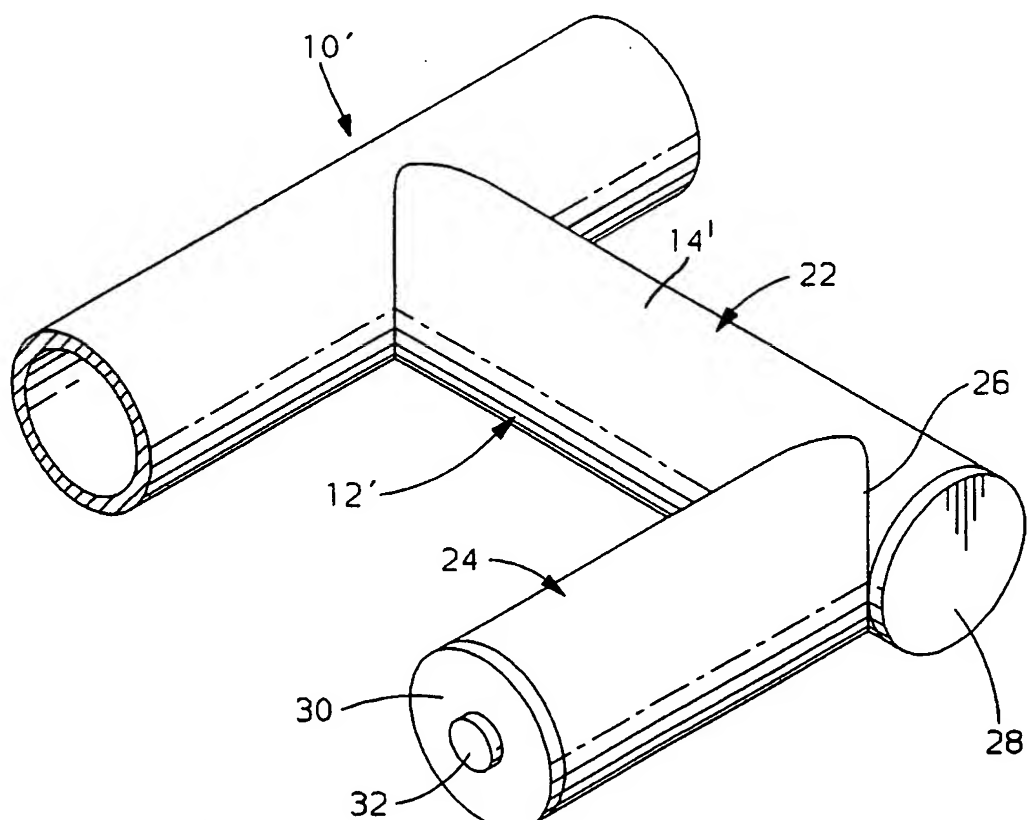

FIG. 2

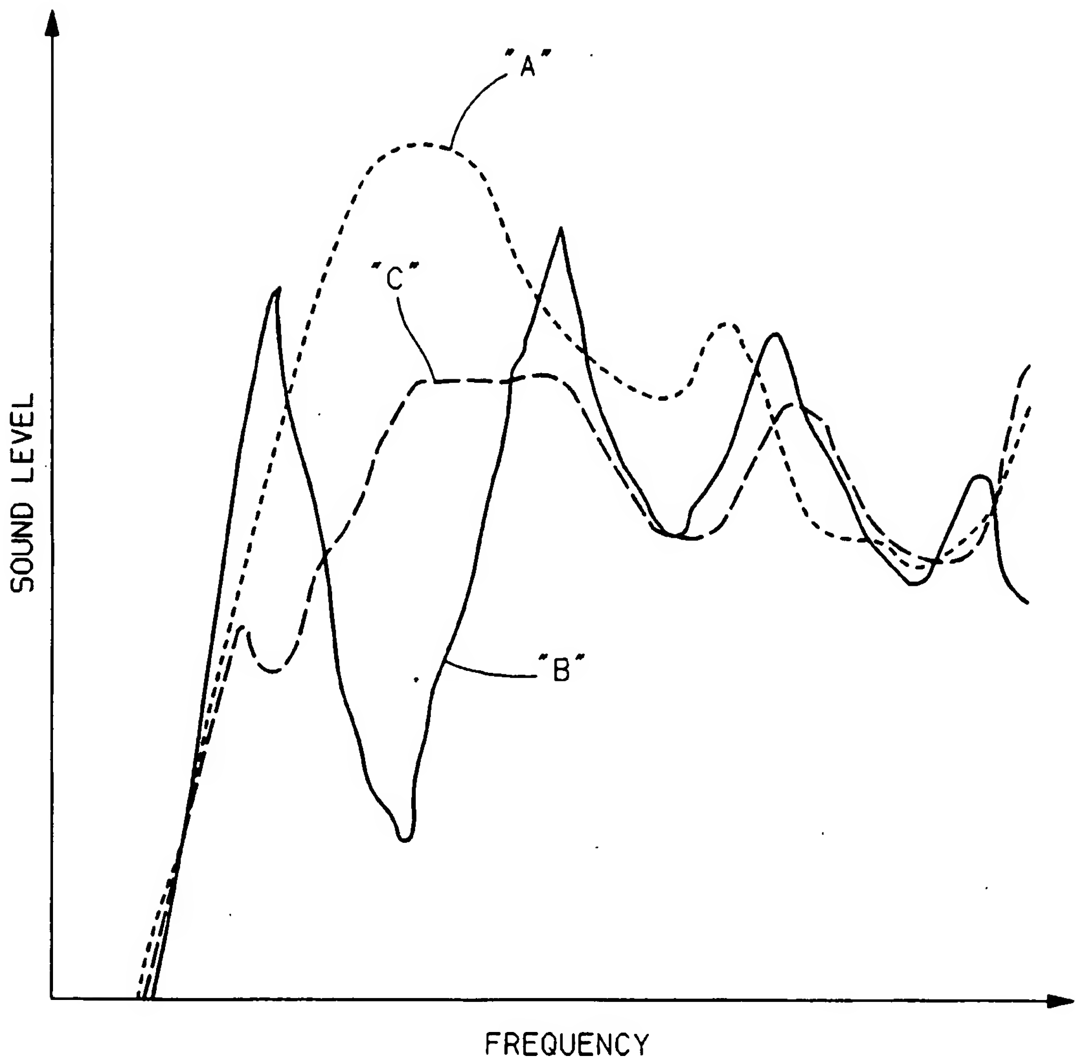

FIG. 3

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EUROPEAN SEARCH REPORT

Application Number
EP 95 20 2130

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
Y	EP-A-0 376 299 (MAZDA) * column 7, line 47 - line 57 * * column 11, line 16 - line 33; figures 3,5 * ---	1,2,5	F02M35/12 F01N1/02
Y	US-A-5 103 931 (OKAZAKI) * column 1, line 29 - line 35; figure 12 * * column 1, line 63 - column 2, line 22 * * column 2, line 37 - line 47 * * column 2, line 55 - line 58 * * column 8, line 63 - column 9, line 7 * ---	1,2,5	
A	PATENT ABSTRACTS OF JAPAN vol. 2, no. 69 (M-021) 25 May 1978 & JP-A-53 032 222 (KAWASAKI) 27 March 1978 * abstract * ---	1,5	
A	PATENT ABSTRACTS OF JAPAN vol. 7, no. 230 (M-249) (1375) 12 October 1983 & JP-A-58 124 057 (TOYOTA) 23 July 1983 * abstract * ---	1,4	TECHNICAL FIELDS SEARCHED (Int.Cl.6)
A	PATENT ABSTRACTS OF JAPAN vol. 11, no. 14 (M-553) (2461) 14 January 1987 & JP-A-61 190 158 (HONDA) 23 August 1986 * abstract * ---	1,5	F02M F01N
A	PATENT ABSTRACTS OF JAPAN vol. 17, no. 21 (M-1353) 14 January 1993 & JP-A-04 246 221 (TOYODA) 2 September 1992 * abstract * ---	1,5	
A	GB-A-2 260 574 (HYUNDAI) * page 3, paragraph 2; figure 5 * --- -/--	1,5	

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	21 November 1995	Joris, J

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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Application Number
EP 95 20 2130

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
A	US-A-5 333 576 (VERKLEEREN) * column 1, line 61 - line 68 * * column 2, line 12 - line 16 * * column 3, line 16 - line 30 * * column 4, line 1 - line 4 * ---	1,5	
A	US-A-1 954 516 (BOURNE) * page 1, left column, line 2 - line 4 * * page 1, right column, line 66 - line 76 * * page 2, left column, line 17 - line 32; figure 2 * ---	1,5,6	
A	DE-U-86 07 920 (ALFA ROMEO) -----		

TECHNICAL FIELDS SEARCHED (Int.Cl.6)

The present search report has been drawn up for all claims

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THE HAGUE	21 November 1995	Joris, J

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